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An investigation of livelihood responses to Lantana camara invasion and biodiversity change in southern India: application of an asset function framework

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An investigation of livelihood responses to *Lantana camara* invasion and biodiversity change in southern India: application of an asset function framework

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Abstract

Natural resources play key roles as assets in the livelihoods of rural communities. However, the benefits of these assets in livelihoods are frequently conceived narrowly as income generating or vulnerability reducing. We contend that they have other important roles to play in poverty reduction and livelihood change. In this paper we use a case study of two ethnic communities in a village in southern India to investigate livelihood responses to change in forest biodiversity through an examination of changes in attributes of natural assets resulting from the invasion of *Lantana camara* and wider socio-economic change.

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Introduction

The importance of biodiversity for poverty reduction is an explicit assumption of key goals and agreements in both conservation and poverty policy arenas (for example the Convention on Biological Diversity, the Millennium Development Goals and ongoing discussions on post 2015 and sustainable development goals). This has contributed to increased attention to the potential role of natural resources in poverty reduction over the past decade (Roe et al. 2014). At the same time there has been growing emphasis on the role of assets (the resources upon which individuals and households construct their livelihoods) in poverty reduction strategies. This stems in part from research into poverty dynamics (eg. Sen 2003; Krishna 2004), which has drawn attention to the importance of household assets, and influenced policy towards strategies which a) reduce the likelihood of people falling into poverty through loss of assets, and b) promote the acquisition of assets by the chronically poor (Carter and Barrett 2006; Shaffer 2008). Asset accumulation is considered to be critical to poverty reduction by increasing household incomes, reducing vulnerability, and by helping to manage risk (MacKay 2008; Moser 2006; Siegal and Alwang 1999). Climate change research has also advocated an asset-based approach for understanding vulnerability and resilience (Prowse and Scott 2008; Heltberg et al. 2009).

There is clearly scope for synergy: if natural resources are conceptualised as livelihood assets, analysis of the role of biodiversity in poverty reduction can draw on insights from research on the role of other assets in poverty dynamics. However, a recent review of research on poverty-biodiversity linkages shows that most work is focussed more narrowly on the role of biodiversity as income source (Roe et al. 2014).

Within livelihoods approaches natural resources are commonly conceptualised as assets or 'capitals' within a framework which identifies assets as natural, human, physical or produced, financial or economic, social, cultural and political, and locational or geographical (Scoones 1998; Ashley and Carney 1999; Bebbington 1999; Siegel and Alwang 1999). However, although this categorisation draws attention to the range of assets important for livelihoods, these categories do not describe the *roles* of particular assets. We contend that understanding the roles of assets in livelihoods is useful for understanding the contribution of natural resources to processes of livelihood change and poverty reduction, and such understanding can also be used to describe the differentiated impact of environmental change within resource dependent communities.

In this paper we describe and test a nuanced typology of assets that strives to capture the multiple roles that natural assets play in livelihoods. We refer to these roles as 'asset functions'. We use this framework to investigate household responses to forest degradation linked to invasion by the weed *Lantana camara* in a village in southern India. The paper begins by setting out a framework for characterising natural assets in rural livelihoods. We then introduce the case study and describe the social, economic and environmental changes facing a village in southern India. The core of the paper is an exploration of households' responses by conceptualising these changes as shifts in the quantitative and qualitative attributes of the natural assets providing key functions within people's livelihoods.

Conceptual framework

'Asset functions'

Within a livelihoods framework 'assets' are conceptualised as the material and social resources upon which households and individuals draw to make a living (Carney 1998:4). Although the importance of asset accumulation for poverty reduction has been stressed (eg. Moser 2006), very few studies have sought to highlight the contribution of different assets to processes of livelihood change: Davis (2011) analyses assets and poverty dynamics in Bangladesh; Dorward et al. (2009) consider the multiple functions of livestock; and Kabeer (2004), discusses 'livelihood ladders'. Davis concludes that "different types of assets play quite different roles in processes of improvement or decline, production or protection" (2011:11). Studies such as these suggest that there is merit in developing a framework that distinguishes the different roles of assets in livelihoods and livelihood change.

In order to propose a typology of asset functions applicable to natural resource assets we draw on empirical insights from Swift (1989), Dorward et al. (2005) and Davis (2011) and identify six functions associated with households' tangible assets (comprised of natural and physical capitals in sustainable livelihoods analysis): 1) 'consumable' assets are those that have a direct use value; 2) 'productive' assets produce new resource flows; 3)'savings' assets allow accumulation or storage of value over time; 4) 'protective' assets provide protection or insurance against shock; 5) 'exchange' assets can be converted to cash income; 6) finally we recognise that some assets have 'social' functions. These are listed with further elaboration in Table 1. It should be noted that assets can, and often do, serve more than one function and may serve different functions for different groups, for example livestock may be primarily a productive asset for some or a savings asset for others (see Guyer 1997).

'Asset attributes'

'Attributes' are defined as the characteristics of an asset that influence its ability to fulfil a certain function. This further elaboration is useful for understanding how environmental change impacts on livelihoods – by considering not only changes in asset stocks – but also the ability of the asset to serve certain functions. Table 2 presents a non-exhaustive list of possible attributes determining assets' fulfilment of different functions. The relevance of different attributes will vary from case to case. Table 2 lists attributes found to be relevant to asset functions identified in the case study presented later.

Asset attributes are context specific social constructs that vary between people with different resource sets, ie. the attributes of a particular assets are conferred/endowed by the context, rather than the product of innate characteristics alone. For example, the 'complementarity' of a particular natural resource asset will be particular to the user, and may be lower for a group who cannot use the resource due to lack of access to other (for example financial, labour) assets required to realise goods and services. Likewise, 'convertibility' will be higher for groups or individuals that can access markets or have knowledge and power to negotiate to their advantage. This highlights the need to analyse attributes for sub-groups of users and not lump all users together: asset-based analysis must focus on the characteristics of both the user and the asset.

Conceptualising biodiversity change as change in the attributes of affected livelihood assets in relation to identified functions can then facilitate an analysis of the social and cultural specificity of change impacts. It can thus provide a tool for considering who will be most affected by change in biodiversity and why, and suggests how negative impacts might be mitigated.

Study site and context

The study village, Kombuddikki lies in the Male Mahadeshwara Hills (MM Hills) forest reserve in Chamarajanagar, the southern-most District of Karnataka. The MM Hills range lies between 11º 55' and 12º 13' N and 77º 30' to 77º 47' E. Two ethnic groups reside in the village: there are approximately 80 Hindu *Lingayat* households and 30 indigenous *Soliga* (a Scheduled Tribe) households.

The Soliga households are mainly nuclear, comprising husband, wife and unmarried children. In contrast Lingayat households are on average larger and more often multigenerational, where married sons remain in the households and farms are worked communally. These observations are consistent with ethnographic accounts of the Soliga which describe a nuclear household organisation (Morab 1977) and more recent household surveys which report differences in average household size between communities (Uma Shaanker et al. 2005; Harisha unpublished data; ATREE 2012). Both communities have kinship links with nearby villages that are accessible by forest paths. These relationships are drawn upon for labour sharing and livestock care.

Livelihoods in both communities are traditionally based on a mix of permanent agriculture (mainly millets as a food staple and some cash cropping of cassava, maize and sunflower), payment for the collection of forest products, basketry from forest bamboo, and livestock rearing (forest grazing). However population growth in the village over the past century without any increase in cultivated land has reduced the land per household for cultivation. This is reported by elderly respondents in the current study who describe the subdivision of land for their children as leaving little more than 'space to put a house', and it is also compatible with comparisons of household surveys carried out in 2000 and 2010 (ATREE 2012). These suggest a trend of falling contributions to livelihoods from agriculture and forest product collection, counterbalanced by increased reliance on wages from labour migration – with men labouring at stone quarries typically for a month at a time 3 or 4 times a year. The surveys also report differences in livelihood strategies between the two communities: Lingayat households earn a greater proportion of household income from agriculture and livestock and from certain forest products such as *Phoenix loureie,* an understory palm. Soliga households, on the other hand, derive an important proportion of income from basket making and forest fruits (Uma Shaanker et al. 2005; Harisha, unpublished data). The present study revealed no evidence of conflict between the two communities over resource use.

The community at Kombuddikki also has access to a village 'fair price' shop, where Public Distribution System (PDS) rations are sold. Households identified as Below Poverty Line (which includes all members of Scheduled Tribes) receive 35kg of subsidised food grains per month. The exact history of the PDS in at the study site has not been examined. However at the national level the PDS was refocused as the Targeted PDS in 1997 with the goal of identifying and reaching those below the poverty line with 10 kg of food grains per month. This was

raised to 20kg in 2000 and again to 35 kg in 2002. Thus the PDS represents an important recent development in household food provisioning.

At the time of the study three NGO supported Self Help Groups (SHGs) operated in the village, all drawing their membership exclusively from the Lingayat community. SHGs provide villagers with alternatives to money lenders for meeting emergency financial needs and also encourage investment in assets for income generation. SHG membership requires small regular saving and provides education on financial institutions.

These broader changes facing the village reflect a pattern of agrarian change that has been widely reported in rural India. The proportion of rural incomes derived from agriculture is falling as households combine farm work with seasonal migration, the local non-farm economy and petty commodity production (Shah and Hariss-White, 2011). The drivers for these changes have been identified as population growth, increased employment opportunities and technical change (Start and Johnson, 2004), the first two of these are certainly in evidence in Kombudikki.

Environmental change

The village lands are surrounded by the dry deciduous forest of the MM Hills forest reserve. The reserve has a long history of disturbance from agriculture, road building, quarrying, and bamboo extraction (ATREE 2012). At present, activity in the reserve is limited to the harvest of forest products under license, firewood collection and grazing of livestock, all activities which are considered to have some impacts on forest vegetation. However, a more serious concern to forest users and managers alike is the invasion of the tropical weed *Lantana camara.* This shrub was estimated to occupy 80% of the reserve in 2001, and is considered a serious threat to forest structure and composition (Uma Shaanker et al. 2010). A highly competitive shrub, lantana forms dense thickets and has the potential to displace native understory vegetation in disturbed forest (Sharma and Raghubanshi 2007). Whilst the ripe berries are palatable and provide a food source for birds and other animals, the leaves are toxic and cannot be grazed (Sharma et al. 2005).

Agricultural land is largely kept clear of lantana through cultivation and weeding, however it rapidly invades lands left fallow. Attempts to eradicate Lantana from forest are more challenging. In the early 1900s the Forest Department pursued physical removal as a strategy but recent policy has shifted to minimizing impacts rather than removal (Bhagwat 2012; Kannan et al. 2013). In the study area some work is carried out to clear lantana from roadsides and paths, but there is no attempt to reduce lantana in the forest itself.

Lantana has become widespread in the forests of India following its introduction in the 1800s (Kannan et al. 2012). Concern over its impact on forest vegetation has been substantiated by recent studies showing negative relationships between lantana density and diversity and abundance of forest species. Sharma and Raghubanshi (2007, 2010) argue that lantana invasion is leading to species loss and the creation of a monotypic understory in dry deciduous forests in India.

In the dry deciduous forest of MM hills, studies have identified a negative relationship between lantana density and species diversity of shrubs and tree seedlings (Avarind et al. 2006). Further investigation into the impact of

lantana on bird distribution, a proxy indicator of changing forest structure, found bird species diversity, species richness, and abundance to be lower at high densities of lantana (Aravind et al. 2010).

Sundaram and Hiremath (2012) report a dramatic increase in the presence and abundance of lantana in the nearby Biligiriranga Hills between 1997 and 2008. This increase has been accompanied by change in native community structure evidenced by a decline in species richness and diversity in deciduous forest and change in size-class structure of tree and shrubs.

The impact of these vegetation changes on local livelihoods is also documented. Sundaram et al. (2012) found that that almost 90% of Soliga surveyed in the Biligiriranga Hills believe that grass and bamboo have declined in abundance due to lantana invasion. These observations are supported by a number of recent studies which report direct and indirect negative effects of lantana on access to forage (Krishna et al. 2008; Prasad 2010, 2012; Ticktin et al. 2012); and distances travelled to collect non-timber forest products (NTFPs) (Poulsen, 2001).

Methods

The village was selected as a case study to examine people's responses to loss of forest livelihood assets within a broader investigation of human adaptation to biodiversity change. The village was selected as a site where: 1) populations had a relatively high dependence on natural resource based livelihoods; 2) biodiversity change threatened these livelihoods; and 3) there was substantial prior information on environmental change and the biophysical context.

Responses of households to changing access to natural resource assets was a key theme of the research, however these responses need to be understood within the context of wider social and economic changes. Hence a range of methods was used to describe people's livelihood strategies and how they have changed over time with and without reference to the forest.

Data collection was divided into two phases; fieldwork took place during July and August and December 2011. Phase one included a rapid census and mapping of the village households to record land and cattle holdings and household structure. Subsequently a series of semi-structured interviews was conducted with men and women from both ethnic groups. Interviews employed historical matrices (Freudenberger 1998), life histories, spending inventories, and interviews about changes in diet and food. In addition two focus groups were held with SHGs, and key informant interviews were conducted with the school headmaster, a SHG administrator and priest. All these data contributed to an inventory of livelihood assets, an understanding of household livelihood strategies and accounts of recent ecological and social change. Participant observation was used throughout the study period and both the researcher and translator resided in the village. This permitted observation of day-to-day activities, of visitors to the village, and of unusual events. Researchers accompanied villagers on trips to the forest for firewood collection and cattle grazing.

Historical matrices were used as a tool to frame discussion of people's experiences of change. The first matrix concerned participation in household livelihood activities (farming, day labour, cattle, goats, bamboo collection, basketry, forest product collection, and quarry labour) during four time periods from the 1960s to the present day. Each livelihood activity was accompanied by a symbol (a line drawing or photograph) and

respondents used small stones to indicate relative importance of each activity over time. A second matrix was concerned with changes in the forest. The same reference periods were used, but this time change in abundance of forest products (grazing, leaves, tubers, bamboo, *Phoenix*) and of lantana was described.

The interviews on household expenditure employed a checklist of possible household purchases and when these had last occurred. These questions served as a starting point to explore where and by whom investment in household assets was occurring and the source of finance.

In the second data collection phase, interviews were focussed on the functions of identified assets in people's lives, past and present. A series of semi-structured interviews was conducted to explore the functions of land and cattle and to examine attitudes to *Phoenix* collection and basket making. Respondents were questioned about what a particular asset was for (for example 'why do you need cattle?') and why it was valued (for example 'what is good/bad about *Phoenix* collection?'). In this way asset attributes were explored both inductively (drawing on perceptions expressed by respondents) and by employing *a priori* categories derived from other work (Siegal and Alwang 1999; Dorward et al. 2005). These attributes are the characteristics that people value in (or that detract from) a particular asset and will vary with context. The important attributes described for forest assets in the current study are described in Table 2.

Interviews were conducted in Kannada and transcribed into English. All qualitative data (field notes, interview transcripts, photographs and film) collected during the field period were managed and later coded and analysed using NViVO.

Results

Change in the forest

In general the forest is considered not as it once was, and these changes are attributed to a range of factors including reduced rainfall, the invasion of lantana and the harvesting of trees and bamboo. An elderly man who arrived in Kombuddikki in the 1970s recalled that at that time:

> *The forest was in good condition. Now it is destroyed by people in different ways… the river flowed all year and there were huge trees all around.*

Similarly an elderly Soliga woman remembers:

> *There was a lot of bamboo, large bamboo clumps in the forest. We were collecting lots of fruits, leaves, tubers – now nothing. The forest was happy then. Now it is not like that because there is no rain. No rain; that is why the forest is not good.*

Elderly informants recalled that lantana first appeared after the bamboo extraction that followed the bamboo flowering in the 1970s. However, a range of informants expressed the belief that it is in the past four to five years lantana has become a significant problem for forest users.

A number of forest products used by villagers (fodder grasses, small bamboos, Phoenix, and wild foods) are perceived to have declined in recent decades. The presence of lantana, smothering and crowding out other

vegetation, is widely blamed for these changes. This is especially the case for grazing resources. The effect of lantana on non-grazing resources was more equivocal since it is recognized that forest resources are also subject to other pressures – be it elephant grazing, harvesting or the effects of reduced rainfall. Nonetheless the presence of lantana was widely lamented for its negative impact on the forest. The lantana-dominated undergrowth makes it difficult to gather forest products, and travel through the forest is slow. The high density of lantana close to the village means that it is now necessary to travel further for many forest products:

> *'We are not at all going to collect muste [a leaf] and sonde [a fruit] nowadays. You have to walk all the way to the foothills and spend the whole day – so we are not getting it anymore. Only lantana is there now'.*

The increased danger of animal encounters, especially elephants, was a recurring theme throughout the research. This risk is mainly associated with poor visibility in the forest due to lantana, and villagers are no longer confident that they can avoid wild animals

The obstruction of smaller forest paths by lantana also means that humans and animals are sharing the same routes thus potentially increasing the likelihood of encounters. Furthermore, lantana adds to the danger when animals are encountered because moving to safety is difficult.

Livelihood change

In the last two decades migration for quarry labour has become increasingly important as a source of income. Men usually work for a month at a time and are paid 200-250 rupees/day received as a lump sum (6000 rupees/month); they also receive food and board. These earnings are often used to pay back loans taken to meet living expenses and they also provide for investments in housing and agriculture.

This change in livelihoods can be linked to declining availability of land for agriculture, improved opportunities for wage labour and reduced viability of cattle rearing in the forest. Migration itself has important impacts on both farming and livestock rearing: some land in the village has been abandoned due to the absence of labour and respondents cite lack of labour to watch cattle as a reason for no longer having large herds.

Joint households in which land is cultivated collectively, appear to have advantages in realising livelihood strategies in which quarry labour is combined with agriculture:

> *If the land is divided in the family it is more difficult. It is better to share because if someone goes outside for quarry work the others can stay and look after the farm and get the crop. Also if someone goes they can come back and get the tractor for rent*.

As discussed above, this type of household organisation is less evident in the Soliga community, and the fact of quarry labour was given by Soliga respondents to explain why land remained uncultivated or land preparation had been delayed. In some cases this has led to the abandonment of land and its invasion by lantana.

For some, the decline in agrarian livelihoods which has been experienced in Kombidikki is explicitly linked to the lantana invasion of the forest:

There was so much grass and bamboo, everyone had 30-40 cattle, and they were selling plenty of milk and ghee. We were prosperous then. Lantana destroyed the forest.

Because of the lantana we cannot lead life. We cannot enter the forest with our cattle. [If we could] then we would not need to go outside for work. But here the forest is no good. If the forest was good the cattle and goats could be grazed and we would live here only.

However, not all villagers see these livelihood changes as negative:

Then [in the past] it was good for food. But for labouring people it was difficult for food. Those who had land and cows were getting enough food. Nowadays if two people are in the house going for quarry labour they can earn 10,000 rupees a month and it is good. But for people like me, only looking after the land, it is difficult. Nowadays those people [labourers] are better off. Cultivating people – if they get [the harvest] things are OK, if not then things are not good. There is no option for us [who can't do quarry work] – only cultivating the land. It's better if parents are looking after the land and sons are going for quarry work.

– if [lantana] had not increased it would be better for the cattle. But then it was different, if one had land. Everyone stayed here and worked, but now some people go outside to work and this has led to increased awareness. Life is better now.

In the Lingayat community the availability of quarry labour combined with a shortage of bamboo is perceived to have contributed to a decline in basket making:

When the bamboo was in the forest Lingayat people were making baskets but now they give up and go for quarry work. It is mainly Soligas making baskets now. It is difficult work going to the forest to get bamboo - 'why should we do this?'- going for quarry work and getting money is easier. They get three times food and 200 rupees per day.

In contrast, Soliga men describe combining basket making and quarry work. Despite the problem of declining forest resources, periodic migration is not seen as a response to lantana invasion but a need for income:

What can we do? Basket making. One day doing it - one day not. If we are free then we do the work. For 7 days we can earn 500-600 rupees. There is more money [in quarry labour] 100 rupees more per day. And they provide lunch and breakfast. Here [in the village] everything has to be bought.

… they are not going to quarry work because of lantana, but to meet their needs for cash, for medicine or loans.

Access to credit

Most Kombuddikki residents borrow money to meet consumption needs and consequently livelihood strategies are frequently discussed in terms of incurring and meeting debts. Thus, the advent of SHGs marks an important change in people's livelihoods for two reasons: First, the ability to access SHG loans is highly valued since these loans attract lower interest rates than those charged by money lenders. Second, SHG membership

demands regular payments the principal way women are able to meet these payments, and thus participate in SHGs, is through income earned from collection of *Phoenix*. In this way SHGs have provided an additional incentive to collect forest products.

SHG loans have been used for various purposes: house building, purchasing cattle for rearing and ploughing, to start a shop or business, and to meet marriage expenses. Loans are also taken out to repay other loans or at times when households cannot meet basic consumption needs. Nonetheless, SHGs are not only valued as a source of loans, one woman explained that her eight years of savings were for when she is older and weaker. Women also describe how participation in SHGs has led to increased 'awareness' and practical skills such as managing bank accounts. Unfortunately, the SHG initiated in the Soliga community in 2006 ran into trouble when members began to borrow more and pay back less: "*everyone got loans and that SHG group got stopped".*

Differential impact of change on key natural assets and their attributes

We now consider the ways in which the socio-economic and ecological changes described above affect key natural assets and the impacts of these changes for different groups. Four forest assets which were prominent in villagers' discussions of their changing livelihoods and illustrative of a range of asset functions are selected for analysis. These are: grasses for cattle grazing; bamboo for basketry; *Phoenix leaves* collected under contract; and wild tubers for consumption. To apply the asset function framework we describe in turn the functions that each resource provides to households, the attributes that enable them to do this, and how they have changed. This analysis is summarised in Table 3.

Forest grazing and cattle

The significance of forest grazing lies in its contribution to cattle keeping. Therefore we will consider both the changing attributes of forest grazing and those of cattle. Local names are given in brackets.

Important forage grasses for Kombuddikki cattle grazers are *Eragrostis burmanica* Bor. (Naale hullu); *Heteropogon contortus* (L.) P. Beauv. (Ulugada hullu); *Themeda cymbaria*, Hack. (Baale hullu); and *Themeda triandra*, Forak. (Belamanchi hullu). The function of these forest grasses (*consumption*) has not changed over time but there is a perceived alteration in important attributes that contribute to this (*productivity*, *security*, *use costs*). Productivity of forest grasses is perceived to have been severely affected by the lantana invasion. Respondents describe a time when the forest was more open, spacious, and 'full of grass'. Now herders feel compelled to travel further into the forest and into more dangerous steep and rocky areas in search of grass; they spend more time grazing and have to move continuously to find fodder. Cattle herders contend that their animals return hungry and weak, and are thus more vulnerable to disease, falls, and attacks by wildlife.

Our data demonstrate that cattle serve a variety of important functions within household livelihood strategies: they are used for ploughing, providing manure, and threshing (*productive* functions). They provide small quantities of milk for consumption (*consumption* function) and income though the sale of male calves, hiring

out for ploughing, and limited milk sales (*exchange* functions). They also serve as an important reserve of value that can be sold when lump sums of cash are needed (*savings* and *protective* functions).

Decline in forage availability has had important impacts on the *productivity*, *use costs* and *security* attributes of cattle. For many households, cattle also have a reduced *exchange* function compared to the past. For those who have retained small livestock holdings (two to four cattle) the increased costs of maintaining cattle, coupled with their increased susceptibility to disease and accidents, reduces the potential *savings* function of cattle. The *complementarity* of cattle grazing as a livelihood activity has also changed with increased labour migration and the associated *risk* is perceived to have increased.

Bamboo and basket making

The functions of the small bamboo, *Dendrocalamus strictus* (chit bidaru), has not changed over time but as with forest grasses there is a perceived change in important attributes (*productivity*, *security*, *use costs*) contributing to its functions.

For the Soliga in particular, basketry serves an *exchange* function and also facilitates access to credit and therefore provides a *protective* function. These functions have largely been lost to the Lingayat who no longer engage in basket making to any significant degree.

To explain the *protective* function of basketry, it should be explained that basket traders regularly make advance payments to their suppliers. In some cases the relationship between traders and weavers is such that traders will forward significant sums (one respondent reported this could be up to 5000 rupees) and therefore act as a source of loans as well as regular income. This function of basket making needs to be taken into consideration in an assessment of its value as a livelihood activity. All households interviewed in the course of the research regularly borrow money, and avoiding the high interest rates of moneylenders is considered one of the primary benefits of the SHG membership. However, the Soliga as a group have not been successful in initiating or sustaining the institutions necessary to access new forms of credit. As a group with fewer assets (land and cattle), they also may be considered less credit worthy than non-tribal households. The relationship with basket traders is therefore important and will continue to be valued where sources of finance are limited.

A critical attribute of basket making to the Soliga is its *complementarity*. Basket-making can be combined with grazing cattle or food gathering activities and migration for quarry labour. This attribute can be seen as of increasing importance with the rise of labour migration as an income source. Basket making is largely an individual pursuit (though households may go collecting together) requiring little or no investment and thus is potentially open to all irrespective of individual or household asset holdings.

Phoenix collection

Phoenix loureie (kasahullu) is collected under contract to be made into brooms. It serves an important *exchange* function for both groups; but for the Lingayat women it also represents an asset important for savings and access to credit, thus fulfilling *productive* and *protective* functions also.

Largely due to its long harvest period (up to six months), *Phoenix* collection is potentially the most remunerative of the forest products extracted under contract. When the contract is issued women typically work four days per week cutting leaves. Payment is per bundle, 20 rupees, and most respondents claim they can manage ten bundles per trip. Incomes ranging from 400-1000 rupees/ week for the duration of the contract were reported by Lingayat women. Soliga women reported earning less, and this appears largely due to fewer days spent collecting.

Collection is carried out mainly but not exclusively by women. Respondents explained that this was due to the higher labour rates that men can expect to earn out of the village. Lingayat women value it as one of the few income earning options available to them in the village and one that pays more than field labour (the rate for which is 50 rupees/day for women). *Phoenix* income was often discussed with reference to the role it plays in providing income for the savings required of SHG members.

There is a perception that *Phoenix* is in decline due to lantana, and that collection takes longer as a result. Women repeatedly expressed concern about the future of this source of income. Again, these concerns involve possible changes in *productivity*, *use costs* and *security*.

Lingayat women valued the *complementarity* of *Phoenix* collection with domestic tasks and agricultural labour demands. Negative attributes were emphasised by the Soliga and related to the *risk* of entering the forest and the dangers of snakes and elephants. Soliga women explained they would rather undertake wage labour in the village even though it earns less. It is possible that lower incentives for income earning by women in the Soliga community may reduce incentives to engage in *Phoenix* collection.

Wild tubers

Wild yams, *Dioscorea wallichii* (benne) and *D. pentaphylla* (noore) are traditionally collected by the Soliga from the forest. The primary function of these wild food assets is *consumption*; they are not collected for sale. Their consumption may contribute to a cultural identity among former forager groups such as the Soliga (one respondent explained: 'this is our food') and therefore provide a *social* function. Wild foods may also serve a *protection* function, providing supplementary seasonal foodstuffs before harvest or in times of crop failure (Harisha and Padmavathy 2013).

Respondents explained that the availability of these foods in the forest has declined significantly in recent years. This has also been reported in studies of wild food use in MM Hills which document the recent abandonment of collection sites due to due to inaccessibility and species loss (Harisha 2012). Food collection often takes place at the same time as other forest based activities (such as grazing cattle), so reduced time spent in the forest may also diminish opportunities for food gathering. In India the PDS is considered to be a factor contributing to the reduced cultivation of traditional subsistence crops (eg. Kothari 1999; Maikuri et al. 2001; King et al. 2008), it may be that the PDS has a similar effect on the use of traditional wild foods. The changing attributes of wild yams associated with the changing forest ecology can be characterized as a decline in *productivity*, *use costs*, and *complementarity* with increased *risk* associated with their harvest. The changing context of food provision increases the *substitutability* of these wild foods.

Discussion

In the present study, we can see that the declining availability of forest products which previously made important contributions to household incomes (forest grasses, bamboo) and diets (wild yams and leaves) coincides with a trend towards village livelihoods that combine seasonal migration with agriculture, collection of forest products and basket making. This follows a pattern of diversification through seasonal migration which has been widely documented in India (Shah and Harris-White, 2011). Migration has important implications for agriculture via the resulting impacts on labour availability and land management (Baka 2013) and these challenges are reflected in the different experiences of Kombudikki households in combining migration with farming activities. The variable impact of these changes in employment on different classes or groups has been noted by Deb et al. 2002 and Djurfeldt et al. 2008 who report that poorer households have benefitted from this (partial) transition out of agriculture. These findings are echoed in the comments by respondents in this study on the differential impact of seasonal migration on farming and landless households and joint and simple households.

Kombudikki households have long practised diverse livelihoods – traditionally combining agriculture, collection of forest products and cattle rearing. Oral histories and interviews around livelihood change suggest that as a group Lingayat households have substituted cattle rearing for labour migration as one component of livelihood strategies within which agriculture continues to play an important role. Thus Lingayat households may be better able to adapt to the recent loss of forest assets from their 'basket' of options. This is due in part to a pattern of household organisation which means that periodic labour migration (the principal alternative to forest based activity) can be taken up with less detriment to agriculture. In contrast, the Soliga appear to be in a more precarious position. Periodic migration has contributed to the neglect of agricultural land (we observed delayed land preparation and land lost to lantana) and leaves cattle holding problematic for small households. Thus for one community, migration provides a means for sustaining agrarian lifestyles (as described by Mosse et al. 2002), whilst for the other it may contribute to its decline.

Joint households permit flexibility in labour allocation and allow households to diversify agrarian livelihoods to include periodic migration. This finding supports those of Djurfeldt et al. (2008) who, in a similar context of increased migration and diversified rural livelihoods, found higher incomes and a lower risk of downward mobility in joint households, an effect they attributed to access to a larger pool of labour. Another potential factor in the relative success of Lingayat households in maintaining agricultural operations is their engagement in reciprocal labour sharing arrangements – a practice not observed between Soliga households. This may be important where increased external opportunities for wage employment impact on the availability of agricultural labour (for example Baka 2013).

Although migration may substitute the exchange function of cattle rearing, it does not provide the *productive*, *savings* and *protective* functions afforded by cattle. Income from migration is used to buy in draught power for land preparation (animal or tractor) and fertiliser, however, the savings role of cattle (and hence their

protective role) is potentially lost. The future impact of this is hard to gauge. The reduction in cattle holdings may mean households are more dependent on loans. At present aside from the small contributions to SHGs (20 rupees/week) few people currently make regular savings. Increased engagement with financial institutions through SHGs may improve people's access to banks. However, this may be limited among poorer households.

In contrast to the reduced dependence on the forest by Lingayat households, forest based activity – principally basket-weaving, remains an important income earning activity among the Soliga. Basket-weaving also functions as an indirect source of credit to Soliga households, helping to meet both day-to-day needs and larger expenses. The decline in availability of bamboo, and therefore the decline in performance of these functions, clearly has greater potential impact on Soliga households.

As discussed above, differences in livelihood strategies may be explained in part by a more individualised social organisation among the Soliga. The single family structure reflects a cultural emphasis on individual autonomy characteristic of forager (or formerly foraging) societies (Gardner 1991). It can be argued that this trait also contributes to the Soligas' limited investment in agriculture and preference for pursuits with immediate return (such as basketry). Thus, whilst we must not ignore the external relationships that reproduce inequalities (Mosse 2010), an apparent failure to maintain land and livestock holdings within the Soliga community may reflect cultural values in this group as has been explored in other south Indian former foraging societies (eg. Norstrom 2003). In the current context, these traits may increase the vulnerability of Soliga households who face declining forest assets at the same time as changing employment patterns reduce the viability of agrarian livelihoods.

In other basket-weaving communities the decline of bamboo has led to its substitution with Lantana (Kannan et al. 2014), indeed NGO projects in MM Hills have encouraged the use of lantana in craft and furniture making. However, whilst these activities offer a potential alternative income source, lantana crafts do not share the same attribute of *complementarity*, nor match the flexibility, low cooperation and minimal investment requirements of basket making which currently help secure its place in Soliga livelihoods in Kombuddikki. The significant challenge of accommodating a lantana craft businesses within diverse and opportunistic livelihood strategies has been described in relation to a lantana crafts project amongst another indigenous forager group, the Kattunayakan, in Tamil Nadu (Thekaekara et al 2013).

The Soliga may adapt to the decline in availability of wild yams by substitution with PDS grains. Hence the *consumption* functions of this asset may be substituted. However, the *social* function of these foods is not replaced. The Soliga are potentially affected by the loss of cultural identity associated with forest gathering. Declining availability of wild foods combined with employment outside the village, increased risks and reduced incentives mean that less time is spent in the forest, leading to loss of skills and knowledge.

So far we have considered the differences in the impacts of loss of forest assets between ethnic groups. The review of contextual influences on changes in asset attributes also highlights gendered impacts of changes in forest assets. In particular a decline in the abundance of *Phoenix loureiri* will have a significant impact on women's income earning potential since they are less likely to leave the village in search of other labour

opportunities. This may have broader implications for households than might be suggested from the loss of the *exchange* function alone since current access to regulated microfinance is largely through women's SHG membership. If women's income is reduced, participation in SHGs may be affected which will affect the capacity of households to secure loans.

Conclusions

The loss of exchange and consumption functions of natural assets is often highlighted in studies of the impact of biodiversity change. The case study of the impact of declining forest resources on the Soliga and Lingayat communities shows that it is important to identify which groups are most affected by these losses and why, but also to pay attention to potential impacts from loss of social functions, savings functions and protective functions and therefore may be important for development outcomes. In the present study highlighting the role of certain natural assets in securing access to credit, emphasises potential impact of resource loss on household's or individual's ability to invest in and accumulate assets which has implications for livelihood change and poverty reduction.

Responses to environmental change need to be viewed in the context of wider socio-economic change brought on by economic transformation and globalisation. The application of an asset function framework with a focus on perceived changes in the attributes of natural assets provides a useful lens through which to look at impacts of environmental change because the functions and attributes of these assets are in part the product of their socio-economic and cultural context. Analysing changes in attributes for different user groups allows the social effects of environmental change to be disaggregated, thus acknowledging social differentiation of impacts which is critical in discussion of the role of natural resources in poverty reduction (Daw et al. 2011).

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Responses to reviewers' comments:

Reviewer #1: The authors provide compelling evidence demonstrating the linkages between biodiversity change and (differential) livelihood responses in South India. Overall, the paper is theoretically sound, nicely structured and will make a fine contribution to the literature. However, the paper will benefit from some additional clarifications/distinctions as detailed below.

1. Tighten the link between the theoretical framework used - asset function framework - and the analysis sections. In the present version, the framework is not really present in the analysis. Revising Table 1 would be a good starting point for reworking this linkage (see next point).

We have reorganised the presentation of the conceptual framework – and expanded the description of asset functions and attributes. Tables are presented for reference (also suggested by reviewer 2).

2. It isn't clear how Table 1 fits into the paper. Mountain dates are not discussed in the body of the paper, for example, nor are many of the comparisons made in the table. It seems a more appropriate table would be a comparison of forest product asset functions for the Solinga and Lingayat and the differential responses to Lantana invasion. Additionally, the asset functions should correspond to the 'asset function framework' presented in the 'typology' section of the paper (pg. 4). Such a table should also be better woven into the body of the text than is the current Table 1.

The analysis section is presented more systematically with references to the framework – Table 1 is revised (now table 3) to include all four assets and consistency in terms used.

Mountain date palm is *Phoenix Loureie.* We have removed all references to broomstick, palm leaves etc. and consistently use *Phoenix.*

3. How, if at all, is the transition out of agriculture impacting lantana invasion? The authors provide various hints throughout the paper- seasonal male migration reducing the agricultural workforce, joint (Lingayat) versus individual households (Solinga) - but given the importance of declining agriculture across India, the topic warrants a more structured discussion. Some useful references to help structure the discussion are (not an exhaustive list by any means): Alpa Shah, Harriss-White, "Resurrecting Scholarship on Agrarian Transformations", Economic and Political Weekly, 2011; G. Djurfeld, et al "Agrarian Change and Social Mobility in Tamil Nadu", Economic and Political Weekly, 2008; also review the July 2013 13(3) special issue of the Journal of Agrarian Change edited by Alpa Shah, Jens Lerche, Barbara Harriss-White.

3a. Along this topic, might seasonal migration contribute towards Lantana invasion (declining labor force means less time spent working the land which accelerates Lantana invasion)?
Baka found such evidence concerning Prosopis juliflora invasion in neighboring Tamil Nadu: J. Baka, "The Political Construction of Wasteland: Governmentality, Land Acquisition and Social Inequality in South India", Development and Change, 2013 44(2).

The transition out of agriculture does have consequences regarding the invasion of lantana into *cultivated land*. There is evidence that fields have been lost to lantana where landowners have migrated for work. This was mentioned in the previous submission and we have brought this into the discussion regarding the different responses of communities to combining migration and village based activity.

3b. Tighten the discussion of quarry work, migration and Lantana invasion. When did the quarries open? When did seasonal migration begin in the study village?

We don't know when the quarries opened – they are many in different locations, and quarrying has occurred in MM Hills itself – so it's hard to get precise information. We have tried to be clear that household interviews report increased quarry labour in the last 2 decades

3bi. What are the wages for quarry work? The authors state they are higher than agricultural work but do not provide specific evidence.

Now added.

4. The authors should also clarify some ecological and economic characteristics of Lantana.

4a. Why can't it be grazed?

A reference to the toxicity of lantana leaves has been made.

4b. Can it be removed? How challenging is this? What attempts have villagers made to remove it?

Have added text on control in farm and forest land.

4c. Does Lantana have any value to the communities? During my fieldwork in Madagascar, it was discussed for possible use in basket weaving. Was it introduced for similar purposes in India? If so, why is it not used for such purposes?

Have added note that lantana is used by some traditional weavers in S India and lantana projects have been running in MM Hills (with refs)

5. Some additional information on the Lingayat/Solinga would also strengthen the paper.

5a. How does the simple difference in population sizes account for the differential responses to Lantana invasion of the Lingayat/Solinga?

We do not feel that the absolute or relative population sizes in the village itself lead to particular constraints or opportunities - both communities have kinship ties with other communities nearby (sharing labour, livestock care). We have added a sentence stating this.

5ai. Why do the population sizes differ so greatly? Has this always been the case? If not, is Lantanta/biodiversity changes contributing to these differences?

Villages are in the region are mixed – some communities have greater numbers of tribal households some less – We don't feel that more can be said without going into the history/origins of the village.

5aii. Why are the Lingayat spread throughout the village while the Solinga are narrowly concentrated?

Government building of housing in the Soliga colony has created this spatial arrangement. The original (founding) families had land at this end of the village. However, we have now taken out the reference to the spatial arrangement since no further analysis is made.

5b. Is there any evidence of biodiversity-related conflict between the two communities?

No evidence of biodiversity related conflict found in the present study. Sentence added.

6. Some additional figures would also be helpful:
6a. A timeline charting Lantana introduction, quarry openings, seasonal migration.
6b. A map of the study region. Include the general location of the two communities as well.

We have not added a time line since precise dating is problematic – the precise date of lantana invasion is unknown and migration opportunities have arisen in different locations over time. . The purpose of the paper has been clarified – that this is an application of a framework rather than a detailed case study.

Similarly we feel the exact location of the study site is not critical for the purpose of the paper and a map risks increasing the length of the paper over the page limit. However, we have included the coordinates of the village for readers who wish to locate the study precisely.

7. Regarding grammar and flow:
7a. Spell out acronyms at first use:
7ai. NTFP (pg. 7)
7aii. BRT (pg. 8)
7aiii. PDS (pg. 10)

DONE
7b. There are a good number of run-on sentences in the paper (ie. pg. 16, paragraph beginning with 'basket weaving').

EDITED
7c. Proofread the paper to ensure proper punctuation. Numerous sentences do not end in periods.
DONE

Reviewer #2: REVIEW COMMENTS: BIODIVERSITY CHANGE AND LIVELIHOOD RESPONSES IN SOUTHERN INDIA: APPLICATION OF AN ASSET FUNCTION FRAMEWORK

General/broad comments

This paper presents a modified assets framework that can be applied to aid in the assessment of the impacts of environmental change, specifically biodiversity change, on livelihood activities and assets and consequently poverty and human well-being. The authors illustrate the usefulness of this framework by employing it to understand how the invasion of the exotic species Lantana camara has affected various aspects of the livelihoods and well-being of two ethnic groups in MM Forest Hills in India.

I liked the framework and the way it was used in the case study and feel that the approach provides a useful and systematic way for studying change in rural communities and households. Further, the detailed understanding that emerges regarding the differentiated social and household impacts of an invasive species like Lantana are also very interesting. I also enjoyed the easy writing style of the authors. But, the structure of the paper needs some major work to make it clearer to the reader what its purpose is and how it is organised. Is this an empirical study of the impacts and responses to Lantana invasion, or a conceptual/methodological paper for understanding environmental change and its consequences that is supported with a case study? At the moment it is somewhat a mix of these and the reader is left a little confused as to where the paper is going, and some sections, such as the one on page 7 on the impact of Lantana on forest biodiversity, come as a complete surprise as no prior mention is made of Lantana and yet it is the focus of a large section of the paper.

The paper is restructured to emphasize that we are testing a framework with the case study.
The introduction has been restructured.
Suggestion for putting the discussion on livelihoods and assets and poverty reduction in the Introduction are taken.

I found the introduction poorly structured and organised, and the opening paragraph a little misleading as no mention is made of Lantana as the driver of forest biodiversity change (rather than biodiversity loss as in the second sentence which suggests local extinction). The introduction would read better if the authors started with some background related to livelihoods, assets and change and then moved into the purpose of the paper, covering this more thoroughly. The final section could outline for the reader how the rest of the paper is structured. At the moment the introduction does not adequately provide the context and aims of the paper. Part of the second section, such as the paragraph at the bottom of page 3 would be better as part of the introduction. I suggest the authors look at ways to merge sections 1 and 2.

In the first couple of paragraphs the authors use biodiversity loss, environmental change, biodiversity change, forest biodiversity change, changes in natural assets, loss of natural resources and even livelihood change somewhat interchangeably - this is confusing and messy and needs to be tightened up and perhaps the concepts even defined. They are not necessarily one and the same thing.

Paper has been reviewed for consistency in use of terms.

The section on a typology of asset function/attributes could be supported by a table or figure that captures these functions for easy reference as the paper proceeds. This would make it easier to follow later sections of the paper.

Section on conceptual framework is expanded and tables included for reference/clarification

The methodology section refers to methods rather than methodology and again could be better structured for improved flow. It is repetitive at the moment, with the first and second paragraphs saying basically the same thing. It is also a little superficial - e.g. nothing is mentioned about the fact that data were collected from two different ethnic groups or that data were specifically related to several key natural assets. This section needs rewritten.

Methods section renamed and revised to detail data collection process

The word "broomstick" makes me think of the handles rather than the brush part of a broom. It would be better to say the collection of palm leaves to make brooms. It took me a while to work out what the authors were referring to.

All references to broomstick, palm leaves, have been removed – consistent reference to Phoenix now.

Study area and context rather than study area, with the section on ethnic livelihood differences being a subsection of the study area and context section.

Done - sub heading removed – ethic differences described within study area and context section, some detail removed as suggested below

It is unclear where the background and contextual information stops and results begin. Page 8 seems to be findings. Can these different parts of the paper be better separated?

Previous work is put in the study site and context section – leaving results section to report on fieldwork findings (mainly)

The sections on the "key natural assets" are not consistent in what is presented across the examples. For example, for some the impacts of Lantana on the 'asset' are described and discussed but not for others (e.g. bamboo). These sections should start with a description of the asset including Latin names, etc., its use, and then the impacts of Lantana on the attributes of the particular asset and then the livelihood consequences of this for the different social groups. More systematic treatment of these examples would greatly assist the reader in following the overall story articulated in the paper.

Each asset is treated systematically as suggested. But not only looking at changes due to lantana.

The section labelled summary seems rather lost and random. The material should be integrated into the previous section and the contents of the table more systematically presented for each of the key natural assets. The table is actually very useful and informative but needs to be better used and referred to in the text/narrative.
Done – have reworked table and section has been revised.

Overall, the paper needs some fairly major restructuring to ensure improved coherence and logical flow before it is publishable.
This includes rewriting the introduction and methods sections, DONE
reorganising the section on key assets as well as DONE

making sure it is clear where in the paper the transition from contextual background to actual results from the study occurs. DONE

As mentioned above the authors need to clarify the nature of the paper - is it reporting an approach and methodology or reporting on local impacts and responses to biodiversity change resulting from the invasion of a non-indigenous species. This subtle difference in the emphasis changes the way in which the paper is best structured. DONE

Specific edits

* The title should be more specific and contain some reference to Lantana as the specific case of biodiversity change.

Title has been changed to: 'An investigation of livelihood responses to *Lantana camara* invasion and biodiversity change: application of an asset function framework'

* In the abstract how do the authors distinguish natural and livelihood assets - are they actually referring to natural assets? Add….. forest biodiversity change through examination of the changes in the attributes of key livelihood assets resulting from the invasion of Lantana. Again, here the authors are using livelihood assets and natural assets to mean the same thing. In the abstract they authors refer to key livelihood assets, later in the paper it is key natural assets. Last line - allows rather than encourages.

Abstract edited and references to 'livelihood' assets removed

* Add Lantana to key words. DONE
* Page 5 - what is amla? REMOVED
* Page 6, 1st paragraph. I found this confusing and contradictory. At one point the authors say Lingayat farms were prepared in advance of the rains, whereas one line down they suggest hey plant late - "Cattle holding is more common in the Lingayat community (which accounts for some of the delay in planting). This needs to be clarified. DISCUSSION ON LAND PREP REMOVED in restructuring
* 27 out of 33 - 27 since it is at the beginning of a sentence should be written out in full. Detail removed
* Page 6, 3rd paragraph - lower than what? REMOVED
* Page 7, Paragraph 1 after quote, line 3 - which land has not been cultivated - what is the land? Removed in restructuring
* NTFP - first time needs to be written in full. DONE
* Break the second and 3rd sentence of the paragraph under impact of Lantana. REVISED
* Page 8, paragraph 5 - what is BRT? DONE
* Page 8, last paragraph - is it changes in the forest or is it Lantana invasion and its impact on the forest? This refers to all change – not just impacts of lantana since it is not possible to verify the causes of change – but respondents did link these to lantana.
* Sometimes Lantana and sometimes lantana. Done – all lantana
* Page 10, 1st line - land holdings not holding. Done/removed
* Page 10 - In India the PDS is considered to be a factor contributing to … by whom? References? ADDED
* Page 10 - middle paragraph - little confusing as previously mentioned that land was not subdivided. REMOVED
* Page 11. Differential impacts of change on key natural assets - what change - Lantana invasion? CLARIFIED ('the socio-economic and ecological changes described above')
* How/why were these assets selected for study. This should even be first mentioned in the methods section. The methods do not set out well the approach to the study and need revised. REVISED

* Page 12, 2nd last paragraph - the question posed seems a little lost as this is not a style used elsewhere in the paper. REMOVED
* Page 14, last paragraph - what wild foods? CHANGED

Table 1. Description of asset functions

Function	*Assets which …*
consumption	have a direct use value, for example direct consumption (foods) or assets used for fuel, or shelter
exchange	fulfill an exchange function, generating exchange value and serving as convertible income or savings
production	produce new resource flows
protection	provide protection or insurance against shock, including spreading risks through diversification or providing a buffering function
saving	allow accumulation or storage of value over time
social	have a religious or spiritual role, or a social function – eg. important for gift giving, or symbolic of social status.

Table 2. Attributes of assets that affect their ability to fulfil certain functions (source: adapted from Dorward et al. 2005)

Attribute	*Explanation*
Complementarity	Does use of this asset require other assets to achieve value? Does the use of this asset preclude the use of other assets/livelihood activities?
Convertibility	Exchange costs. How easy it is to convert this asset into cash or other investment or consumption resources?
Use costs	The costs of accessing and utilizing a resource
Productivity	'Normal' productivity; sensitivity to and resilience under different conditions
Rules of access	Rights and responsibilities for access
Security	Risks to asset, future availability of resource
Risk	Risks to user. Can this asset be accessed/used without risk of harm?
Social value	Does the holding/use of this asset confer/reduce social status or other social capital? Does it contribute to identity, group belonging, heritage?
Substitutability	Can the services provided by this asset be substituted by another?

Table 3. Functions of four forest assets and recent changes in their attributes

Asset	Primary functions	Secondary functions	Change in attributes	Response
Grazing	Consumption (L, S)*	via cattle: Productive (L); savings (L, S); protective (L, S); exchange (L); social (L); consumption (L)	Reduced complementarity (with quarry labour) Increased use costs (time taken for grazing) Reduced productivity Reduced security – future availability uncertain Increased risk to grazers Increased substitutability – income alternatives from migration	Reduction in herd size, substitute income from migration (L, S)
Bamboo	Consumption (L, S)	via basketry: Exchange (S), protective (S)	Increased use costs (time taken) Reduced productivity Reduced security – future availability uncertain Increased risk to collectors Substitutability – low for Soliga; high for Lingayat (migration)	Substitute income from migration (L)
Phoenix	Exchange (L, S)	via SHG membership: Protective (L), savings (L)	Increased use costs (time taken) Reduced productivity Reduced security – future availability uncertain Increased risk to harvesters Increased substitutability – for men – low substitutability for women	None yet
Tubers	Consumption (S), protective (S), social (S)		Reduced complementarity (less time in forest) Increased use costs (time taken) Reduced productivity Reduced security – future availability uncertain Increased risk to harvesters Increased substitutability (consumption function)– PDS	Reduced consumption, substitute grains from PDS (S)

*(L) and (S) refer respectively to Lingayat and Soliga livelihoods